EXAMINING THE RELATIONSHIP BETWEEN MUSICAL APTITUDE AND AUDITORY PHONOLOGICAL PATTERN RECOGNITION IN SINGLE- AND MULTI-SPEAKER LANGUAGE CONTEXTS

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Research has demonstrated that musical aptitude is closely associated with a range of linguistic abilities, highlighting the interrelation between these two faculties. Musicians are often characterized by fine-grained auditory skills that emerge through both innate aptitude and systematic training. Consequently, an increasing body of research has shown that individuals with advanced musical skills tend to outperform those with lower musical proficiency across several cognitive domains, most notably in the acquisition of foreign languages. This advantage is particularly evident in early stages of language learning, when learners must rely primarily on acoustic parameters before fully establishing connections to semantic context.

We sought to determine whether fine-grained auditory abilities underlie the relationship between musical aptitude and language performance in initial learning contexts, particularly when learners are exposed to unfamiliar linguistic material. We examined whether musical aptitude is differentially related to language performance by contrasting a *Single-Speaker* task, which places high demands on fine-grained auditory discrimination, with a *Multi-Speaker* task, which introduces greater variability in auditory input and relies less on precise auditory acuity.

Musical aptitude measures were strongly interrelated and showed the expected gradient of association with speech tasks (stronger in Single-Speaker vs. weaker in Multi-Speaker conditions). The findings suggest that musical aptitude plays a pivotal role in contexts where refined auditory discrimination is required. The findings suggest that musical aptitude plays a pivotal role in contexts where refined auditory discrimination is required. By contrast, in settings involving multiple speakers and languages, its influence weakens substantially and appears to play a minor role.

Keywords: musical aptitude, language aptitude, fine-grained auditory skills, musicality

1. INTRODUCTION

Musical aptitude has garnered increasing interest over the past decade, not only within music research but also across various other scientific domains. This growing attention can be attributed to multiple factors, including the suggestion that understanding the underlying components of musical aptitude may also illuminate processes in other cognitive areas (Christiner 2020, 12-13). Therefore, understanding the underlying dimensions of musical aptitude could provide valuable insights for developing new approaches to facilitate learning processes, not only within the musical domain but also in related cognitive areas.

Generally speaking, aptitude is defined as a complex ability that predicts high achievement and represents an individual's inherent potential within a specific domain (Jørgensen 2008). It distinguishes individuals who are predisposed to perform above their peers in that area (Gagné 2004; Gagné 2008). According to aptitude research, this potential transforms into talent when an individual actively engages in relevant activities. Aptitude manifests and stabilizes more readily at younger ages but can still be observed and assessed in adults by measuring the speed of new skill acquisition (Gagné 2004, 2).

Musically gifted individuals possess enhanced auditory discrimination abilities, enabling them to detect subtle differences in pitch and rhythm within musical sequences (Seither-Preisler, Parncutt and Schneider 2014, 10938). They also tend to perform superiorly in other music-related domains that are crucial for high-level musical performance, such as selective attention and inhibitory control (Joyal et al. 2024, 166). Consequently, musical aptitude measures encompass a range of tasks designed to capture how quickly and accurately individuals perceive, discriminate, and remember musical elements fundamental to auditory processing. Therefore, musical aptitude assessments typically evaluate consonance/dissonance discrimination, pitch contour/harmonic perception, style recognition, melody memory, and sensitivity to loudness/pitch/intensity (Bentley 1966; Gordon 1967; Gordon 1979; Gordon 1982; Gordon 1989; Law 2012; Law and Zentner 2012; Seashore 1919; Seashore 1919; Wallentin et al. 2010). Most common measures, however, focus on melody/rhythm via same-different discrimination of unfamiliar sequences such as the *Advanced Measures of Music Audiation* (*AMMA*) developed by Edwin Gordon (Gordon 1989, 1-3).

Following the discussion on musical aptitude and its measurement, it becomes evident that language aptitude measures share numerous similarities, both in the underlying cognitive processes involved – such as auditory discrimination, memory, and pattern recognition – and in the methodologies employed to assess these aptitudes. Consequently, research indicates that the productive, perceptual and processing mechanisms engaged in musical and linguistic aptitudes overlap significantly, suggesting a potential transfer and interplay between these domains (Christiner et al. 2021; Christiner and Reiterer 2013; Christiner and Reiterer 2019; Coumel et al. 2023; Milovanov 2009; Milovanov and Tervaniemi 2011; Patel 2007). Language aptitude assessments frequently employ unfamiliar tasks designed to evaluate not only the accuracy but also the speed of language acquisition, thus providing a comprehensive measure of an individual's efficiency in acquiring new languages. The *VORD* test utilizes an artificial language structurally similar to Turkish, which typologically differs considerably from Western European languages (Parry and Child 1990, 3-5). In contrast, the *LLAMA* test employs a made-up language based on Central American languages, designed to be language-neutral and applicable to a target audience with diverse native languages (Meara 2005, 2-4). Additionally, the *High-Level Language Aptitude Battery* includes subsections assessing phonemic discrimination with Hindi stimuli, an English pseudo-contrastive test, and phonemic categorization with Russian stimuli, targeting

participants from varied linguistic backgrounds (Doughty et al. 2008, 15-17). Given the fine-grained auditory skills required for these tasks, it is unsurprising that empirical evidence consistently shows strong associations between musicality and early foreign language acquisition. For instance, studies have shown that musical ability is associated with duration perception in speech (Chobert et al. 2014), speech segmentation (François et al. 2013), speech perception (Christiner 2020) , speech processing (Besson, Chobert and Marie 2011), pronunciation accuracy (Christiner et al. 2023; Christiner, Bernhofs and Groß 2022; Christiner, Rüdegger and Reiterer 2018) and the capacity to mimic foreign accents (Coumel et al. 2023).

Collectively, research demonstrates a robust correlation between musical aptitude and phonetic proficiency, particularly in contexts requiring the discrimination of highly similar or unfamiliar auditory stimuli. Such demands are characteristic of foreign language acquisition, where learners must discern subtle phonetic contrasts. The transfer of musical aptitude to linguistic ability thus appears most salient when precise auditory discrimination is essential for distinguishing linguistic units like words and phrases (Christiner and Groß 2025, 12-13). This scenario is often encountered at the onset of language learning or in controlled instructional environments where a single foreign language instructor delivers input. Conversely, in naturalistic settings, especially within European multilingual contexts where multiple speakers and languages coexist, the reliance on fine-grained auditory discrimination – and thus the influence of musical aptitude – may be attenuated.

We aimed to investigate whether musical aptitude is differentially associated with language tasks that demand fine-grained auditory processing compared to tasks where such detailed discrimination is less critical. To this end, we designed a task wherein a single speaker articulates a sequence of different words or phrases in an unfamiliar language, followed by a response prompt. Participants are required to determine whether the response was present in the sequence (*Single-Speaker condition*). This task primarily engages fine-grained auditory processing skills and has been shown in previous research to be strongly associated with musical aptitude (Christiner and Groß 2025, 11). Conversely, we developed a complementary task characterized by reduced demands on fine-grained auditory discrimination. In this task, multiple speakers produce sequences in different languages, and participants must again decide if the response was part of the sequence (*Multi-Speaker condition*). This paradigm introduces greater variability in auditory input and thus relies less on nuanced auditory acuity for successful performance.

We hypothesized that the advantage conferred by musical aptitude would be especially pronounced in situations demanding fine-grained auditory discrimination, as musical aptitude is closely linked to enhanced auditory resolution and timing skills that facilitate the detection of subtle acoustic differences crucial in such contexts. Conversely, we hypothesized that conditions involving multiple speakers would show a weaker or no association with musical aptitude.

2. METHODS

2.1 Participants

We recruited 349 participants through online platforms, schools, and universities, providing them with information about the eligibility criteria they needed to meet. First, participants should neither speak nor comprehend Tagalog, Mandarin, Farsi, Turkish, or Japanese as a second, third, or foreign language. This should simulate a foreign language learning setting in initial learning stages when individuals listen to unfamiliar utterances that they retain for a short period. This should ensure that participants had no prior knowledge about any of the languages included in the research design. The mean age of the participants was 25.22 years (SD = 12.1); 212 were female, 133 were male, and 4 indicated a non-binary gender.

2.2 Testing procedure

The entire testing procedure was conducted online. Participants were provided with individualized login credentials to access the study platform. Initially, they completed a questionnaire assessing their linguistic and musical background. This information confirmed that none of the participants spoke any of the languages included in the experiment and provided additional details regarding their musical training and experience. Subsequently, participants performed the language task, followed by the assessment of musical aptitude. Both the language and musical tasks included familiarization trials that participants could repeat at their discretion. After the familiarization phase, each experimental trial was presented only once.

2.3 Musical aptitude

The AMMA test (Advanced Measures of Music Audiation, Gordon 1989) was utilized to evaluate participants' music perception abilities. This test presented participants with pairs of musical statements, prompting them to identify whether these pairs were identical or exhibited rhythmic or tonal differences. Rhythmic variations included changes in tempo, meter, or duration, while tonal differences involved discrepancies in a few notes between the two statements. The melodies are played on the piano and based on Western harmony. Compared to many newer musicality measures, the AMMA test's complex and lengthy sequences suggest it assesses a combination of musical skills. The test comprised 33 items, with participants completing three practice trials followed by 30 experimental trials. Of these, 10 pairs were identical, 10 differed rhythmically, and 10 differed tonally. The order of presentation for the trials was randomized. For the analysis in this study, we used the composite score (AMMA total) that consists of the results of all trials.

2.4 Auditory phonological pattern recognition

The auditory phonological pattern recognition task used in this study comprises language strings that are either spoken by a single speaker (*Single-Speaker condition*), or by multiple speakers (*Multi-Speaker condition*) encompassing different speakers

and languages. Each string contains eight, ten, or twelve constituents or phrases, with complexity depending on the task level. The length of these constituents varies between one and eleven syllables. After listening to a given string, participants are presented with one, two, or three comparison phrases and must decide whether these phrases appear within the original string. Each correct identification contributes one point to the participant's score, forming the core scoring mechanism. The test included five languages: Tagalog, Mandarin, Farsi, Turkish, and Japanese. In the Single-Speaker condition, five trials were presented for each language, ensuring that all participants were exposed to multiple examples from every language. Typological differences among the languages played only a minor role (Christiner et al. 2023), the inclusion of several linguistically diverse languages primarily served to enhance the reliability of the measure. In total, the test includes 12 *Multi-Speaker items* and 25 *Single-Speaker* items. In the *Single-Speaker* language condition, more fine-grained auditory processing abilities are required compared to the *Multi-Speaker* condition where such detailed auditory discrimination is less critical.

This difference arises from the varying nature of linguistic cues in each condition. In the *Multi-Speaker* condition, the diversity of languages and speakers provides many distinctive cues, enabling listeners to recognize phrases using broader, less detailed auditory information. Conversely, the *Single-Speaker* condition demands heightened sensitivity to subtle phonetic and prosodic details within a single linguistic system, requiring more precise auditory analysis to distinguish similar elements.

3. RESULTS

3.1 Statistical analysis

First, we present the descriptive statistics of the two language measures and the AMMA test. Subsequently, we conducted correlational analyses to examine the relationship between these variables. We wanted to determine whether musical aptitude is more strongly associated with the Single-Speaker condition than with the Multi-Speaker condition.

3.2 Descriptives

Table 1 below presents the means and standard deviations of the main variables under consideration.

Table 1 represents the descriptive of the variables

Variables	*Mean (M)*	*Standard Deviation (SD)*
Multi-Speaker total	*7.23*	*2.19*
Single-Speaker total	*16.39*	*3.08*
AMMA Score	*51.68*	*8.91*

3.3 Correlational analysis

The correlational analysis indicates that musical aptitude is significantly associated with both language variables. Importantly, the relationship with the fine-grained *Single-Speaker* condition, which required highly detailed auditory processing abilities, was considerably stronger than with the *Multi-Speaker* condition, in which such auditory precision played a less critical role (see Table 2 for the values).

Table 2 shows the correlational analysis for the variables under consideration

	Multi-Speaker total	*Single-Speaker total*	*AMMA Score*
Multi-Speaker total		*0.413 ** *	*0.130** *
Single-Speaker total			*0.349** *

p < 0.05 (uncorrected, two-tailed). p < 0.01 (uncorrected, two-tailed).*

4. DISCUSSION

The results of the correlational analyses demonstrated significant associations between musical aptitude and both language perception conditions. Notably, as hypothesized, the strength of this relationship was greater in the fine-grained (*Single-Speaker*) condition, which requires highly detailed auditory discrimination abilities. This suggests that musical aptitude, likely through enhanced auditory resolution and temporal processing skills, plays a more critical role where precise perception of subtle acoustic cues is necessary. In contrast, the *Multi-Speaker* condition, characterized by greater linguistic variability and multiple speaker cues, may allow for more reliance on broader, less specific auditory information, resulting in a comparatively weaker correlation. These findings indicate that musical aptitude is differentially associated with performance depending on the auditory processing demands of the linguistic context.

The *Single-Speaker* condition in our study, characterized by the presence of a single language, places strong demands on fine-grained auditory processing. The phonological pattern recognition task of this study parallels musical aptitude tests by employing novel stimuli (melodies or phonological sequences) that require pure acoustic processing and engaging similar cognitive mechanisms (sound classification, pattern recognition, memory). This could indicate a relationship between music and auditory phonological processing (Christiner and Groß 2025, 12). Similar relationships have been established by extensive interdisciplinary research demonstrating substantial overlap between the neural and cognitive mechanisms underlying music and speech processing (Asaridou and McQueen 2013; Ding et al. 2017; Patel 2007; Patel 2011; Peretz et al. 2015; Perrachione et al. 2013; Rogalsky et al. 2011; Wong et al. 2007). Enhanced musical perception and musical aptitude correlate with improved speech perception abilities (Besson, Chobert and Marie 2011; Chobert et al. 2014; Christiner et al. 2022; Coumel et al. 2023; François et al. 2013; Ho, Cheung and Chan 2003; Moreno 2009; Wong and Perrachione 2007), including duration perception (Chobert et al. 2014), speech

segmentation (François et al. 2013), pitch discrimination relevant to tone-syllables (Christiner et al. 2022), and general speech processing (Besson, Chobert and Marie 2011). Most studies have focused on fine-grained perceptual abilities, which aligns well with the findings of our study.

The findings of this study have significant implications for understanding the intersection between musical aptitude and language perception. One important implication of our study is that the *Single-Speaker* condition closely resembles typical foreign language learning environments, where often a single teacher delivers instruction. In such settings, individuals with higher musical aptitude clearly demonstrate an advantage in discriminating novel linguistic input, presumably due to their enhanced fine-grained auditory processing skills. This demonstrates that the design of learning systems and the structure of learning environments, particularly in the context of foreign language learning, influence the cognitive demands placed on learners, thereby facilitating or hindering the learning process. Another crucial aspect is that musical aptitude plays a significant role in initial foreign language acquisition but may be less important in later stages. For instance, research has shown that unfamiliar language material perceived as more melodic tends to be retained, memorized, and retrieved more quickly (Christiner et al. 2021, 9-10). Consequently, raising participants' awareness not only of the musical features inherent in languages but also of the benefits of their own musical abilities for early learning processes may be essential to facilitate faster acquisition of the phonetic elements of new language material.

In the *Multi-Speaker* condition, the presence of multiple languages and different speakers provides a wider array of distinctive cues, allowing listeners to rely on coarse-grained or global perceptual markers for phrase segmentation and identification. This reduces the reliance on fine-grained auditory discrimination, as specific speaker- and language-specific features serve as anchoring points. Consequently, musical aptitude appears to be less predictive of speech perception performance in contexts featuring multiple speakers and languages. This scenario predominates outside structured educational environments, suggesting that musical abilities may be less critical for language perception and acquisition in naturalistic, multilingual communicative settings.

To date, there are no known studies that have investigated or compared perceptual performance related to musical aptitude across tasks involving two distinct speech conditions: *Single-Speaker* versus *Multi-Speaker* and multi-language environments, specifically with adult speakers for whom all languages were unintelligible. Although this study does not allow drawing causal conclusions based on the correlational analysis, our results shed light on critical discrepancies between laboratory testing conditions and real-world language learning settings. Specifically, they underscore the necessity of reintegrating experimental paradigms with ecological validity to better translate scientific findings into practical applications. In addition, the results of our study have important implications for both language and music research. They underscore the need for more nuanced experimental designs that incorporate contrasting conditions –

such as the *Multi-Speaker* versus *Single-Speaker* speech environments employed in our study – to more comprehensively delineate the benefits as well as the limitations of musical aptitude. Such an approach facilitates the development of a detailed taxonomy categorizing positive, neutral, and negative effects of musical ability on language perception and learning. By broadening the scope of investigation beyond homogeneous conditions, future research can better capture the complex interactions between musical skills and language processing in ecologically valid contexts.

5. CONCLUSION

Our study shows that musical aptitude is closely related to initial foreign language ability due to fine-grained auditory skills that facilitate faster memorization of unfamiliar utterances. The results of this study suggest that, in contexts characterized by greater linguistic variability and multiple speaker cues, listeners may rely on broader, less specific auditory information, thereby reducing the strength of the observed association between musicality and auditory–phonological ability. Therefore, this study not only substantiates the close interrelation between musical and language aptitude but also delineates the specific learning contexts in which musical aptitude proves most advantageous for language acquisition, as well as those in which its influence is more limited. This nuanced understanding facilitates a systematic identification of conditions under which positive transfer effects from music to language are maximized and when they are diminished. By clarifying these contextual boundaries, the findings contribute to a more precise framework for future research and practical applications aimed at leveraging musical skills to enhance language learning outcomes.

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SUMMARY

This study explores the intricate relationship between musical aptitude and foreign language learning, emphasizing the pivotal role of fine-grained auditory skills. Musical aptitude, shaped by innate ability and systematic training, equips individuals with superior auditory discrimination, which significantly benefits the early stages of language acquisition, particularly when learners are exposed to unfamiliar linguistic material. The research contrasts language performance in contexts requiring precise auditory discrimination, represented by a *Single-Speaker* task, with more variable *Multi-Speaker* settings that offer broader and less specific auditory cues. Findings reveal that musical aptitude strongly correlates with language performance in the *Single-Speaker* condition, highlighting its role in supporting fine auditory discrimination skills critical for memorization and processing of novel utterances. Conversely, this correlation weakens in *Multi-Speaker* scenarios, where linguistic variability and multiple speaker cues reduce dependence on detailed auditory acuity.

These results not only reinforce the close interrelation of musical and language aptitudes but also elucidate the contextual boundaries in which musical aptitude influences language learning. By clarifying the specific environments where positive transfer from musical skills to linguistic proficiency is maximized or diminished, this study provides a nuanced framework for understanding how musicality can be leveraged in language education. The findings underscore the necessity for future research to adopt ecologically valid experimental designs that reflect real-world multilingual communication settings, enabling the development of targeted interventions that harness musical abilities to enhance language acquisition outcomes effectively.

This comprehensive understanding contributes to advancing theoretical knowledge and practical applications, situating musical aptitude as a significant but context-dependent facilitator of language learning success.